
Firm: Physical Sciences Inc.

Contract Number: NNX12CF35P

Project Title: Rip-Stop Reinforced Thin Film Sun Shield Structure

Identification and Significance of Innovation: Future NASA telescope missions such as WFIRST, TPF and TPI need very large, very lightweight reflective membranes to provide for both sunshades and large coronagraphs. In addition to being lightweight, the membranes must be strong enough to be tensioned tightly to maintain the separation of insulation layers or the shape of occulter. State of the art membrane technologies are fundamentally limited in their thickness by the strength and rip propagation of the material. Very thin material punctures easily and, once punctured, tears propagate rapidly, causing thermal shorts in the insulation, or light leaks in an occulter, solar sail or sunshield. The large areas of these systems means that even small changes in thickness can substantially modify the mass of both the membrane and the structure that supports and tensions the layers. A design borrowed from the construction of leaves and insect wings has been applied to the thin film membranes where a vein and membrane wing architecture is mimicked through the incorporation of robust, lightweight RipStop to reinforce thin polymer membranes. Space debris impact damage, in space deployment and terrestrial handling damage to thin film membranes can be localized biomimetically through the use of RipStop reinforcement.

Technical Objectives and Work Plan: The Technical Objectives include creating a pilot scale apparatus to deposit RipStop reinforcement on CP1 film, using FEA modeling to optimize the RipStop configuration and demonstrating RipStop reinforcement with increases in load and toughness properties at low mass penalty. The Work Plan started with a meeting with NASA technical staff to discuss and fine tune program goals. PSI then fabricated the electrospinning RipStop deposition system for 0.5 meter wide CP-1 film processing. The Finite Element Analysis was performed at NeXolve to correlate the ripstop placement and geometry effect on the membrane strain profile. We measured tear resistance and strain profile measurements of the fabricated RipStop reinforced membranes. PSI and NeXolve developed a technology scale-up design and plan. The documentation and reporting was comprehensive and includes this Final Report.

Technical Accomplishments: Work performed under the Phase I SBIR yielded a RipStop reinforced CP-1 film with a 3X increase in toughness and elongation and a 2X increase in maximum load when compared to CP1 film without reinforcement. These improvements are achieved for a 5 micron thick film with the addition of a 25 cm pitch, 60 mg/m reinforcement, resulting in a mass increase of 7%. This low mass penalty film reinforcement technology will provide toughness gains while packaged into an existing launch volume or enable thinner films to be substituted with lower mass and equivalent tear resistance.

NASA Application(s): Space durable films are used for large deployable structures such as solar sails for photon propulsion, sunshades for passive thermal control and as planet finding external occulter. Future NASA telescope missions such as WFIRST, TPF and TPI need very large, very lightweight reflective membranes to provide for both sunshades and large coronagraphs. The addition of PSI's nanofiber based RipStop reinforcement to a film will enhance its toughness, elasticity and improve tear resistance and tensile strength. The RipStop reinforcement process is planned to be incorporated into NeXolve's film production line. NeXolve's partner, Bron Aerotech, will provide commercialization and marketing support.

Non-NASA Commercial Application(s): Many non-NASA uses of membrane technology could benefit from the nanofiber reinforcement provided by the electrospun ripstop process. Separator membranes for batteries could be made thinner, while maintaining robustness and resistance to electrode shorting using electrospun reinforcement. Filters made of nanofibers, such as HEPA filters, would have high mechanical strength and lower pressure drop through the use of nanofiber ripstop. Other applications for electrospun reinforcement may include barrier membranes for chemical agents, enhanced robustness for gas separation membranes, and improved thermal film insulation. PSI has strong working relationships with Espin technologies and Donaldson Corp., both commercial manufacturers of electrospun materials and potential partners for the nanofiber reinforcement development proposed in the document.

Name and Address of Principal Investigator: Dr. John D. Lennhoff, Physical Sciences Inc., 20 New England Business Center, Andover, MA 01810-1077

Name and Address of Offeror: Physical Sciences Inc., 20 New England Business Center, Andover, MA 01810-1077